RESEARCH AS AN AID TO COTTON AND COTTONSEED IN MAINTAINING MARKETS[1]

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It is a privilege to be invited to address this conference on the part being played by the Southern Regional Research Laboratory in present-day chemurgic achievements in the cotton and cottonseed industries. The aim of research in the regional laboratories of the Department of Agriculture is by definition identical with that of chemurgy -- "the application of chemistry and the allied sciences to the industrial utilization of raw materials obtained from agricultural commodities."

I do not need, I am sure, to remind you that it is urgent to extend the usefulness of the two farm products we are immediately considering. You are undoubtedly well informed on the competition which cotton and cottonseed are facing from other materials. It is now being very widely admitted that the future consumption of cotton products depends a great deal not only upon the discovery of new utilizations but also upon the maintenance of present uses in undiminished volume. And these, in turn, depend upon the success which scientific research may have in the next few years in improving quality and/or performance in specific uses. Only a favorable quality-price relationship, as compared with competing materials, will enable cotton and cottonseed to maintain, much less extend, their present markets.

Cotton, still the world's leading fiber, was facing a declining market in the years before World War II; but the extremely heavy wartime demand for cotton goods rapidly checked the slump. The same war needs which were favorable to cotton's situation, however, also gave cotton's chief rivals -- rayon and paper -- the opportunity to flourish. The increased demands for rayon were accompanied by remarkable technological progress in the industry, with the result that the qualities of the synthetic fiber were greatly improved. This improvement, when it is combined with the fact that rayon staple fiber -- as of March 15, for example -- cost the mills 4 cents less per pound of usable fiber than did cotton of average grade and staple, places rayon in a postwar position which seriously challenges cotton. While cotton is still the best all-round fiber and is superior to rayon in many important natural

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qualities -- such as strength, durability, launderability -- it is surpassed by rayon in a few other properties. If the rate of improvement of rayon continues at the same pace in the years ahead, it may overtake cotton even in its present advantages. Unless there is matching advance in cotton technology, the price of cotton will have to be relatively much lower than at present, if it is not to surrender large segments of its markets.

No less in need of research to reinforce its position is cottonseed, which has attained the status of a very important product of the crop. Competition is increasing from several other oil-bearing seeds, notably soybeans, recently being produced in larger quantities. Improvement is very much needed in the current methods of processing cottonseed, and new processes must be developed, if better-grade cottonseed oil and meal are to be obtained at lower costs.

Cotton and cottonseed receive a large share of attention in our utilization research at the Southern Laboratory. Many of our investigations are of the type which may take a number of years for complete solution. First of all, fundamental laboratory research is conducted for the collection and application of data on chemical, physical, and technological properties. Next, engineering development is undertaken in the pilot plant. The final step, when a project reaches the point at which this is justified, is to seek the collaboration of industry in commercial-scale trials. The seven years since the opening of the Southern Laboratory in New Orleans is a relatively short period, therefore, for gauging the value of our contributions to industrial progress. But while the term spectacular is perhaps not descriptive of all the work that we have done, our accomplishments clearly point the way to several rather important commercial developments.

To illustrate this I have selected a few of our major projects on cotton and cottonseed to describe to you here. These concrete examples are typical of the way in which modern research is preparing these products to meet the challenge to their present markets.

COTTON FIBER RESEARCH

Improving rot resistance. One of the quality elements in which cotton is lacking is in resistance to attack by mildew and bacterial rot. Yet cotton has other qualities which make it desirable for many uses which subject it to severe degradation of this type. The chemist has therefore been up against the problem of finding a treatment to aid cotton in resisting this deterioration. And indeed numerous treatments have been found which improve cotton's resistance in this respect; but most of these involve the addition of chemicals imparting qualities to the finished product which limit its usefulness — for instance, they may produce objectionable color, odor, or stickiness, or render the material poisonous.

In contrast, scientists at the Southern Regional Laboratory have developed a method which produces the desired effect by a change in the fiber itself rather than by the addition of chemicals. With this treatment the cotton fiber is not so much made resistant to rot as it is actually changed into a new compound which is itself rotproof. This is accomplished by a process called partial acetylation -- part of the cellulose in the cotton is converted into cellulose acetate, a compound highly unpalatable to the rot-causing micro-organisms.

The Southern Laboratory was the first laboratory in the United States to thoroughly explore the rotproofing possibilities of partially acetylated cotton, originally tried in England. We first applied the process during World War II to cotton sandbags. The results clearly demonstrated the superiority of the acetylated cotton in resisting the destructive bacteria. The chief advantage of this method over other rotproofing treatments is that it does not change the form or appearance of the fiber and does not produce any of the objectionable qualities I previously mentioned. The treated material, upon a sufficient degree of acetylation, becomes virtually a new fiber with new properties, and is adaptable to additional utilizations.

One of the important uses for the acetylated fiber is in bags for home water-softening systems. Plain cotton already possesses the high abrasion and tear resistance, the easy and rapid drainage, and the filtering action needed in such bags; but the bags must also be unaffected by hot water, must be nontoxic and odorless, and above all must be rot- and mildew-resistant. When cotton is modified by partial acetylation, it meets all these requirements -- acetylated bags have been intact and serviceable after a year whereas untreated bags rotted after a week. One water-softening bag manufacturer has adopted the process commercially. Favorable reports are coming from the fishing industry which is trying acetylated cotton cord and rope in gill nets in actual service in the Great Lakes. A shoe retailer is testing acetylated cotton linings in men's shoes, a use in which rotting has long caused discomfort to the wearer as well as trouble for the retailer and the manufacturer.

Acetylated cotton has many other possibilities for industrial applications. We are looking into its use as a re-enforcing material in several plastic articles in which the good resistance to heat and electricity and the good dimensional stability which acetylated cotton possesses are of importance. Modified yarns and fabrics are being continually produced on a semicommercial scale at the Southern Laboratory to obtain the samples desired for tests by industrial firms and potential consumers.

Protecting cotton from light degradation. The wide utilization of cotton in such outdoor products as awnings, tarpaulins, and shade cloth, just to mention a few, is another reason why it is important to find weatherproofing treatments that will be effective without adversely affecting essential textile properties.

Work at the Southern Laboratory has shown that, next to mildew, the photochemical action of sunlight degrades exposed cotton more than any other element of weather. Exposure data accumulated by our scientists on representative cotton fabrics have provided a basis for selecting chemicals or treatments which protect cotton in specific classes of outdoor service.

One interesting application of these data was in the formulation of a treatment for use on cotton shade cloth by Florida tobacco growers. Shade-grown tobacco commands a premium in the market which explains why about 60 million yards of tobacco shade cloth is annually produced from cotton. Untreated cotton is fairly rapidly degraded by sunlight, and tobacco growers are asking for weather-resistant cotton that would be more economical for use as shade cloth. This would undoubtedly result in larger acreages of tobacco being covered by cotton. Our research at the Southern Laboratory showed that certain pigment treatments are effective for the purpose, and are also practical from the

finishing standpoint and in respect to cost. Short lengths of the cotton cloth have been treated in our laboratory, and our technicians have supervised treatments of larger samples in Florida. The treated cloth is now being tested in the Florida tobacco fields.

For other weatherproofing uses, where mineral pigments would prove objectionable because of the color they impart to the fabrics, as in awnings, we have found that a colorless resin finish is effective in reducing damage by sunlight.

Improving cotton tire cord. Cotton's utilization in tire cord is receiving a great deal of attention by the cotton industry, and rightly so, because more cotton is consumed in tire fabrics than in any other single use. Our research on tire cord at the Southern Laboratory has included attempts to develop chemical treatments to improve durability, mechanical treatments to improve uniformity, and fundamental studies to determine the complex relationship of fiber structure and properties to performance in service. We have also investigated several varieties of cotton to evaluate their relative advantages for use in tire fabrics.

One significant development of our research is a new mechanical device for stretching cotton tire cord so as to improve its uniformity in regard to strength and elongation under various loads. In usual commercial practice, cotton cord is stretched by a fixed percentage of its original length. This tends to pass on into the finished cord any nonuniformity throughout the length of the unstretched cord. Our scientists have used another principle in attacking this problem; they have applied constant tension during the stretching process, so that portions having a high stretch are pulled down more than those having lower stretch, with the net result of evening out the differences in elongation originally present. The effect is greater uniformity with regard to strength. Our new stretching machine, working according to this principle, produces a stronger cord with better elongating properties than obtained on present commercial machinery. Two tire cord manufacturers have indicated their intention of building similar units, and several other firms are considering the commercial possibilities.

Although for a long time cotton tire cord has performed satisfactorily in passenger car tires, its adequacy for use in large-size, synthetic rubber truck tires has been questioned in recent years. But highway service tests now being conducted by commercial trucking firms operating out of New Orleans on tires using three types of regular-production cotton cord are proving that these standard commercial cotton cords are satisfactory for use in moderately large tires in high-speed, medium-overloaded service. In other tests where the tires were subjected to loads less than their rated capacity, some of the tires have gone more than 175,000 miles without failure on the trailer wheels. These highway tests are providing tire performance data being used in research at the Southern Laboratory on the development of improved types of cord, particularly for large truck or bus tires.

A new dye test to detect immature cotton. Underdeveloped, or immature, cotton fibers require special manufacturing techniques. When their presence is unknown in mill lots they cause difficulties during processing. Besides this disadvantage, immature cotton is inferior in yarns and fabrics for certain uses. Thus a method of detecting immaturity of cotton provides a means of

reducing waste and trouble during processing and also may lead to the production of better-grade products.

A technique for showing up immature fibers has been developed at the Southern Laboratory. Immaturity is distinguished by the selective -- and rather mysterious -- attraction of mature and immature fibers for red and green dyes, respectively. The method is simple enough so that it can be applied as easily in a textile mill as in a laboratory. Both dyes are applied to the fibers in the same bath -- the first example, so far as we know, of cross-dyeing untreated cotton two colors in the same bath.

Although the reason why mature and immature fibers dye differently is not fully understood, it is clear that the degree of thickness of the cell wall, which indicates the degree of maturity, is the basis for the different dyeing effects. Immature fibers have relatively thin cell walls as compared to those of mature fibers. It has long been known that very immature fibers do not dye normally. But up to now there has been no utilization of dyes to develop a test for showing up these thin-walled fibers. The development of our differential dyeing technique therefore provides the cotton industry with a new research tool which has far-reaching applications.

The technique has been successfully applied to solve several different manufacturing problems. Several mills are applying it to classify unknown cottons and to select cottons according to character for different manufacturing purposes. While the technique does not permit the direct quantitative separation of the differently colored fibers, the total color effect obtained in a sample does indicate roughly the amount and distribution of mature and immature fibers, and can be used for the estimation of the average maturity of the sample. Good qualitative correlation has been observed in a set of dyed samples containing from 78 to only 22 percent of mature fibers. Cotton breeders are finding the technique useful for showing up varietal differences with respect to maturity or immaturity -- information which will aid in the development of new varieties and in determining the characteristics of existing varieties under different environmental conditions.

COTTONSEED RESEARCH

Cottonseed processing. No doubt you are all familiar with what has been referred to as the "Cinderella story" of cottonseed. Nevertheless I believe it will be of interest to summarize this story briefly here as background for my discussion of our current research at the Southern Laboratory on improving existing methods or developing new methods of processing cottonseed for oil and meal.

Before the Civil War cottonseed was a waste which piled up at the cotton gins and was finally disposed of by ginners as fertilizer. The crushing of the seed for oil began to be a well established industry in about 1870. As the value of the oil in shortening, foods, soapmaking, and other industrial uses came to be known, cottonseed milling grew phenomenally, and cottonseed came to be foremost in United States oilseed consumption. It held first place for several decades, surrendering this position only in 1944 to soybeans.

While during the years improvement has been made in overall efficiency of operation and equipment in cottonseed mills, the methods of extracting the

oil and meal have remained practically unchanged for at least the past 20 years, and little has been done to solve some of the major problems. Over and above everything else is the need to keep overhead at the lowest possible cost because of the seasonal nature of the industry. The two methods in general use, the hydraulic and screw-press methods, have met minimum requirements and are capable of producing a high-grade oil and meal. But both these methods have two great disadvantages: They do not give complete recovery of the oil from the press cake; and they require pre-cooking of the seed at high temperatures with consequent damage to the protein component. If the almost 5 to 7 percent of the oil remaining in the meal could be recovered from the approximately 2 million tons of cake and meal produced yearly in the United States, cottonseed oil production could be increased by 200 million pounds. And if damage to the protein could be either eliminated or substantially reduced, this would represent a great gain to the industry by providing meal more suitable for livestock feed and also adaptable for new industrial uses. The control of color is a third major problem in processing cottonseed which has not been satisfactorily solved by commercial methods. This, roughly, is the situation which those conducting utilization research on cottonseed are attempting to improve.

In our cottonseed investigations at the Southern Regional Laboratory we have sought a greater understanding of the unique system of pigments contained in cottonseed which differentiates it from other oilseeds and complicates its processing. We have studied the pigment problem particularly as it relates to the color and nutritional quality of cottonseed products obtained by different methods of processing. It has long been known that the conditions of cooking the seed before processing have an effect on the color and nutritional quality of the expressed oil and meal. First in laboratory-scale and then in mill-scale experiments our chemists have investigated the effect of pre-cooking the seed, with and without added moisture, on the final pigmentation and quality of the oil and meal. The large-scale trial runs were actually made in a South Texas oil mill.

Some of the products obtained from these mill-scale tests are being investigated for nutritional properties in the laboratories of two leading universities. At the University of Chicago experiments have been conducted on the relative protein nutritional values of the screw-pressed meals. At Columbia University the relative toxicities of the corresponding oils have been investigated. The experiments with the meal have shown that, contrary to previous conceptions, meal from the wet-cooked, screw-pressed seed was of poor nutritional quality, in contrast with the high nutritional value of meal from dry-cooked, screw-pressed seed. The experiments on the oils have shown that screw-pressed oil from wet-cooked seed is nontoxic while that from dry-cooked seed is initially toxic. This toxic factor, however, can be removed by standard refining procedures. One practical result of these nutritional studies is that the cooperating Texas company has instructed its mills to convert to dry-cooking for processing cottonseed by the screw-press method. This company feels that the increased nutritional value of the meal would more than compensate for any additional difficulty that might be experienced in refining the oil. Investigations now in progress indicate that processing conditions are possible that will give simultaneously meals of high nutritional value and oils of prime color quality without increasing the cost of production.

Another line of our cottonseed processing investigations has dealt with evaluating the advantages and disadvantages of the solvent-extraction method.

At the Southern Laboratory we have been a pioneer group in the experimental solvent extraction of cottonseed. Only recently has this method of extraction been applied to cottonseed on a commercial scale in the United States. Five plants using solvent extraction equipment and processing have been constructed this past year for handling cottonseed. These are now in full operation or in experimental production. The method has two immediate advantages which are, first, that it removes nearly all of the oil from the meal; and, second, that it does not require the cooking of the seed which damages the protein in the other processes.

In our investigations of solvent extraction we have again given attention to the natural pigments contained in cottonseed. In early work on the problem, we discovered that most of the pigments occur as a gelatinous suspension within the gland walls. In attempting to separate the glands from the surrounding tissue, our chemists worked out a method by which the cottonseed meats can be divided into three distinct fractions: intact, or unruptured, pigment glands; an oil-solvent mixture; and an essentially oil-free, pigment-free meal. The recovered oil is relatively light-colored and is of a high-grade commercial quality; the meal has been found highly nutritious for both feed and food uses; and the protein extracted from the meal is of a quality suitable for use in nonfood products. Our engineering division has this fractionation method under development as a step in the solvent-extraction process for cottonseed. It is not yet ready for commercial application -- a good deal of research remains to be completed before its feasibility for industrial use can be definitely determined. Our experimentation has reached the pilot-plant stage, and several large cottonseed oil producers are cooperating with us in adapting the process to commercial practice.

Better-quality cottonseed products. In development research at the Southern Laboratory we have obtained by the new fractionation method more than a thousand pounds of the cottonseed meal and nearly a hundred pounds of the pigment glands for utilization investigations.

In cooperative poultry feeding experiments it has been found that with the new-type, deglanded cottonseed meal as the source of vegetable protein in the diet, with or without addition of a supplemental growth factor, chicks had excellent growth. The hatchability of eggs laid by hens fed deglanded meal as the sole source of protein was also superior. During storage of eggs from hens fed deglanded cottonseed meal, the whites did not turn pink and fewer yolks became discolored. All of these results are significant to the poultry industry because the growth factor for chicks has previously been found only in fish solubles, high-grade meat scraps, and other feeds which have been in short supply.

The pigment glands have possibilities for certain industrial uses as antioxidants and plasticizers, and also certain pharmaceutical uses. The experimental quantities obtained are being investigated at the Southern Laboratory and at a number of other laboratories, with respect to chemical, physical, and physiological properties of the components and derived products.

Cottonseed storage. When moist cottonseed is stored it undergoes changes, or stages of decomposition, which represent a great hazard to individual oil millers. And this deterioration of cottonseed during storage also causes serious monetary losses annually to the industry as a whole. Therefore, the

development of better methods of reducing this spoilage is another cottonseed problem to which attention is needed.

Chemists at the Southern Laboratory have sought a more effective means of meeting the difficulty than that offered by the present aeration methods in general use. Finding that certain chemicals were very successful in preventing changes in the seed during storage, they developed a treatment which consists of applying small quantities of a special chemical to the seeds while they are being conveyed to the storage bins. It appears that when further details have been worked out, the new method may prove economically feasible on a commercial scale.

CONCLUSION

I could cite many other examples of what we have accomplished in our investigations to aid cotton and cottonseed. But I believe that the projects I have discussed are sufficient to indicate the importance of a comprehensive research program on these products if new industrial uses are to be found or existing utilizations are to be improved. I believe that they suffice to show that ensuring the future markets of these products is bound up inseparably with such research objectives as those which are guiding our studies at the Southern Laboratory.

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